Kalman Filter for E895

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The fixed target experiment [1] E895 at BNL faces with its new dataset, Au+Au at 2–8 AGeV, a very high charged particle multiplicity environment in the EOS TPC. Thus a new pattern recognition algorithm based on the Kalman filtering method [2] has been developed. We follow the approach described in [3]. The algorithm starts from a small track segment and then extends the candidate track by adding measured points one by one. The fitted track parameters and the weight matrix of the candidate track are updated when adding a point, thus providing a better precision on the prediction of the next point.

The EOS TPC operates in a 1 Tesla dipole field and the coordinate system is chosen such that z is the beam direction and x the horizontal plane, y is the drift direction. The track parameters are chosen to be the following: For a certain distance z in the detector the helix parameters are $\mathbf{p} = (x, y, sin(\phi), tan(\lambda), \omega)$, ϕ is the turning angle in the bend plane, λ the dip angle, ω the signed curvature. Suppose the track parameters p and the corresponding weight matrix W are known at a certain point. First a prediction $\mathbf{p^e}$ and $\mathbf{W^e}$ is obtained by extrapolating the track to the next padrow. Among all the measured points $\mathbf{x^m} = (x^m, y^m)$ within a window around the extrapolated point $\mathbf{x^e}$ the closest point is selected to be a candidate point. In order to add a point $\mathbf{x^m}$ to the track and to update the track parameters the following χ^2 ansatz is made:

$$\chi^2 = \delta\mathbf{x^T}\mathbf{U}\delta\mathbf{x} + \delta\mathbf{p^T}\mathbf{W^e}\delta\mathbf{p}$$

$$\begin{array}{ll} \delta\mathbf{x} = \mathbf{x^m} - \mathbf{x} & \\ \delta\mathbf{p} = \mathbf{p^e} - \mathbf{p} & \end{array} \qquad \mathbf{U} = \begin{pmatrix} 1/\sigma_x^2 & 0 \\ 0 & 1/\sigma_y^2 \end{pmatrix}$$

Minimizing χ^2 w.r.t. the updated track parameters $\mathbf{p}$ ($d\chi^2/d\mathbf{p} = \mathbf{0}$) gives a system of linear equations $(\mathbf{W^e} + \mathbf{U})\delta\mathbf{p} = \mathbf{U}\delta\mathbf{x}$. Its solution gives the fitted parameters $\mathbf{p}$. The updated weight matrix is $\mathbf{W} = \mathbf{W^e} + \mathbf{U}$.

This procedure has been implemented in a way that takes care of the magnetic field distortion properly.

As another tracking upgrade the so called smoother has been implemented: It happens sometimes that the track is split into 2 or more pieces. This reduces the track finding efficiency significantly. To cope with this problem, a trace-back procedure is invoked. We start from $\mathbf{p}$ and $\mathbf{W}$ at padrow n and extrapolate back to padrow (n-1). One of the following 3 possibilities can occur:

1. A point is found where no point existed during the filter step, the point is added.
2. The new point is the same as the old one, nothing needs to be changed.
3. The new point is different from the old one, the old point is removed and the new point is added.

In our experience this has recovered many missing points and relinked many split tracks and has therefore greatly improved the track–finding and point–finding efficiency.

References

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